Tractor-trailer efficiency technology, cost, and payback assessment

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CARB-SCAQMD Symposium
Diamond Bar, California
April 22, 2015

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Overall project scope
- Research objective, approach
- Tractor-trailer technology feasibility results
- Tractor-trailer technology payback results
- Conclusions

Overall scope: Tractor-trailer assessment

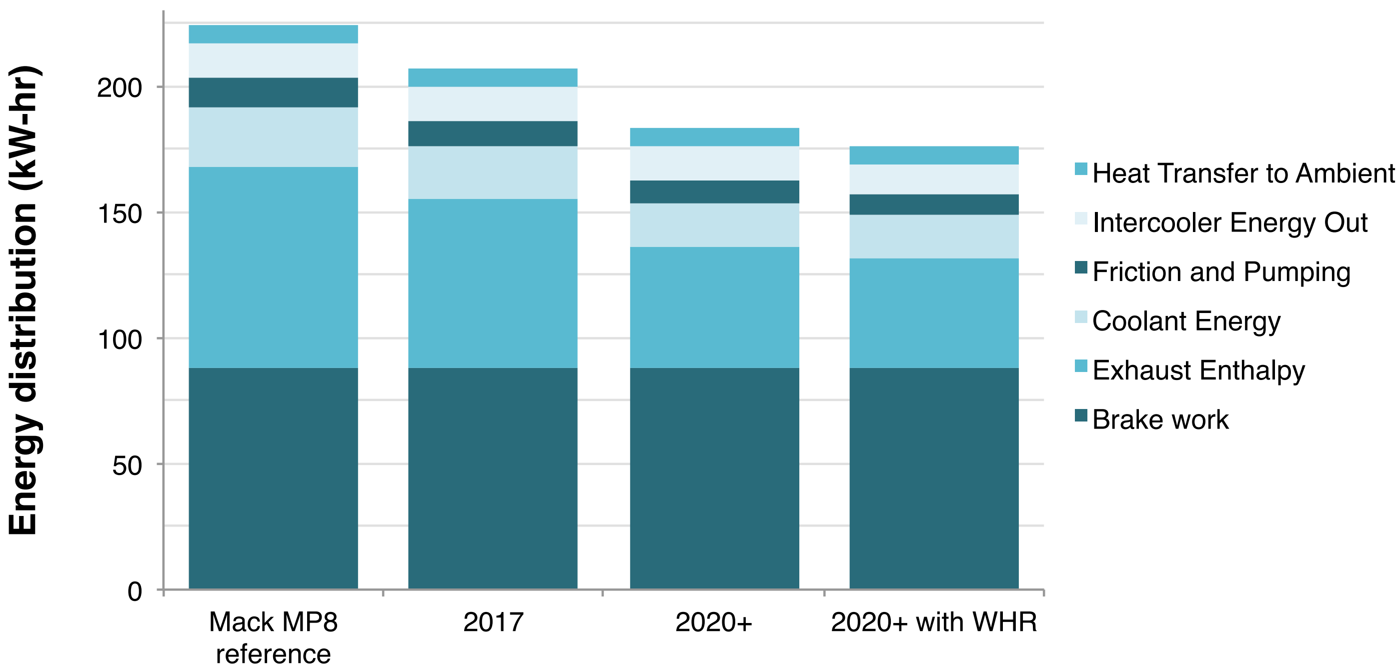
- Project components
  - **Trailer** technology and cost assessment (July 2013-Feb 2014)
    - *http://www.theicct.org/trailer-technologies-increased-hdv-efficiency*
    - *http://www.theicct.org/costs-and-adoption-rates-fuel-saving-trailer-technologies*
  - Analysis of **SuperTruck** technologies (June 2014)
    - *http://www.theicct.org/us-supertruck-program-expediting-development-advanced-hdv-efficiency-technologies*
  - Stakeholder workshop to solicit leading **industry technology input** (Aug 2014)
    - *http://www.theicct.org/stakeholder-workshop-report-tractor-trailer-efficiency-technology-2015-2030*
  - Assess **regulatory design** and test procedures (Oct 2014)
    - *http://www.theicct.org/us-phase2-hdv-regulation-design-options*
  - **Engine energy audit** from laboratory data collection (Nov 2014)
    - *http://www.theicct.org/heavy-duty-vehicle-diesel-engine-efficiency-evaluation-and-energy-audit*
  - Tractor-trailer **simulation modeling of** technology potential (April 2015)
    - *http://www.theicct.org/us-tractor-trailer-efficiency-technology*
  - Tractor-trailer technology cost and **payback period assessment** (April 2015)
    - *http://www.theicct.org/us-tractor-trailer-tech-cost-effectiveness*

Research objectives and approach

- Objective:
  - Assess heavy-duty tractor-trailer efficiency potential in the 2020-2030 timeframe
- Tractor-trailer technology feasibility
  - New diesel engine laboratory data for engine maps, engine audit
  - Input from efficiency technology developers (Bosch, Cummins, Daimler, Eaton, Honeywell, Navistar, Volvo, Wabash, DOE SuperTruck teams)
  - State-of-the-art vehicle simulation modeling (DOE’s Autonomie) to assess system interactions between engine, transmission, aerodynamics, rolling resistance, lightweighting efficiency technologies
- Tractor-trailer technology cost assessment
  - Inputs from leading technology cost assessments (National Research Council, ICF, TIAX, AEA, Ricardo, DOE, EPA/DOT Phase 1)
  - Evaluate payback period with data and assumptions consistent with EPA/DOT regulatory analysis of fuel price, discount rate, vehicle activity by age, technology cost learning, etc

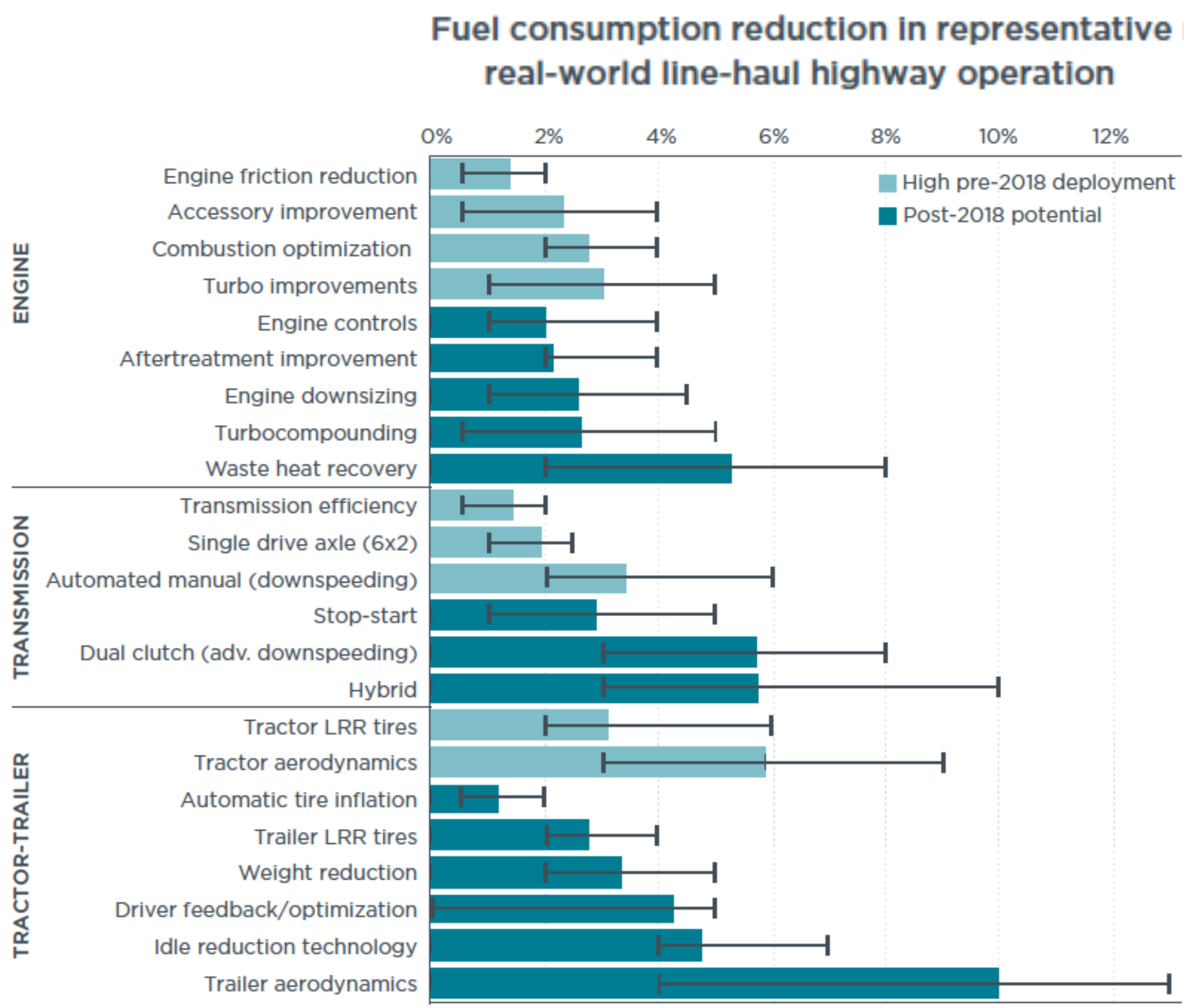
Tractor-trailer engine data

- In collaboration with West Virginia University
- Data collection for engine compliant with US EPA 2010 regulations
  - Engine fuel consumption map (fuel use vs torque, rpm)
  - Energy audit: breakdown of engine loss characteristics



Supplemental Emissions Test (SET) cycle. From Thiruvengadam et al (2014).
http://www.theicct.org/heavy-duty-vehicle-diesel-engine-efficiency-evaluation-and-energy-audit

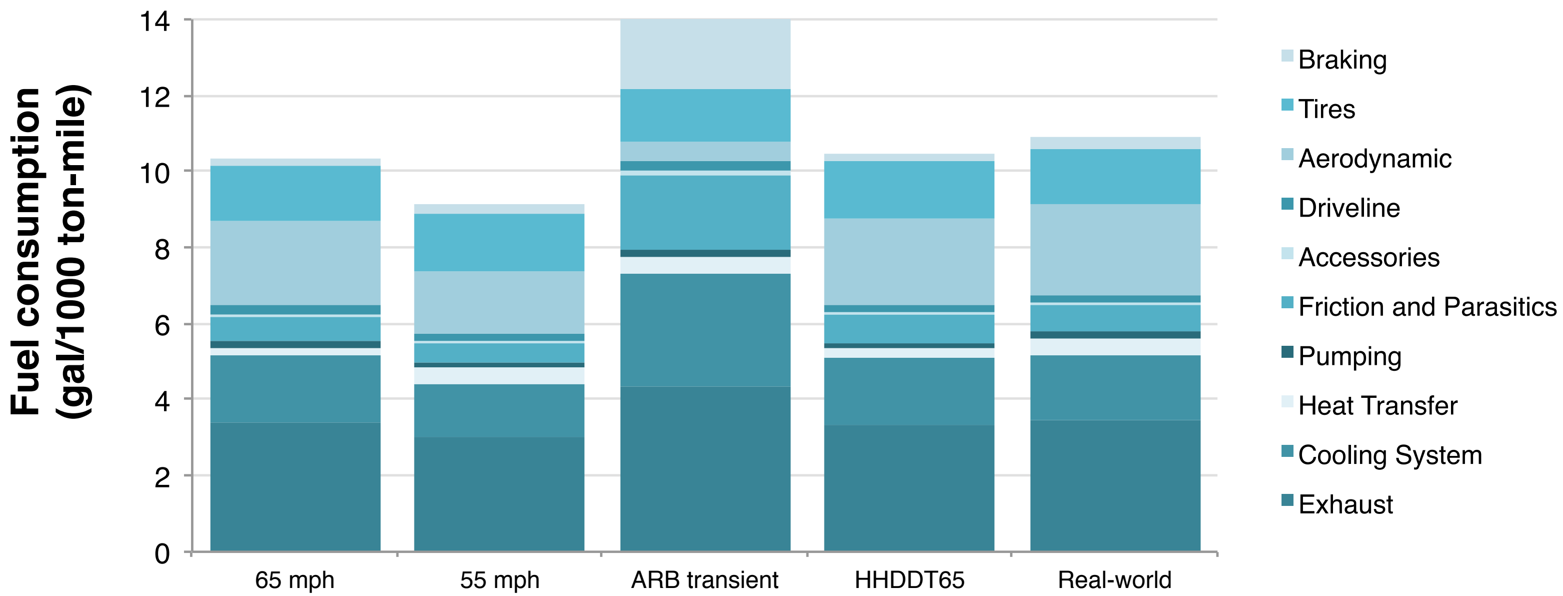
Tractor-trailer efficiency technologies



From July 22, 2014 HDV stakeholder workshop with OEMs, suppliers, research groups, NGOs, government agencies. Lutsey et al (2014). http://www.theicct.org/stakeholder-workshop-report-tractor-trailer-efficiency-technology-2015-2030

Tractor-trailer modeling

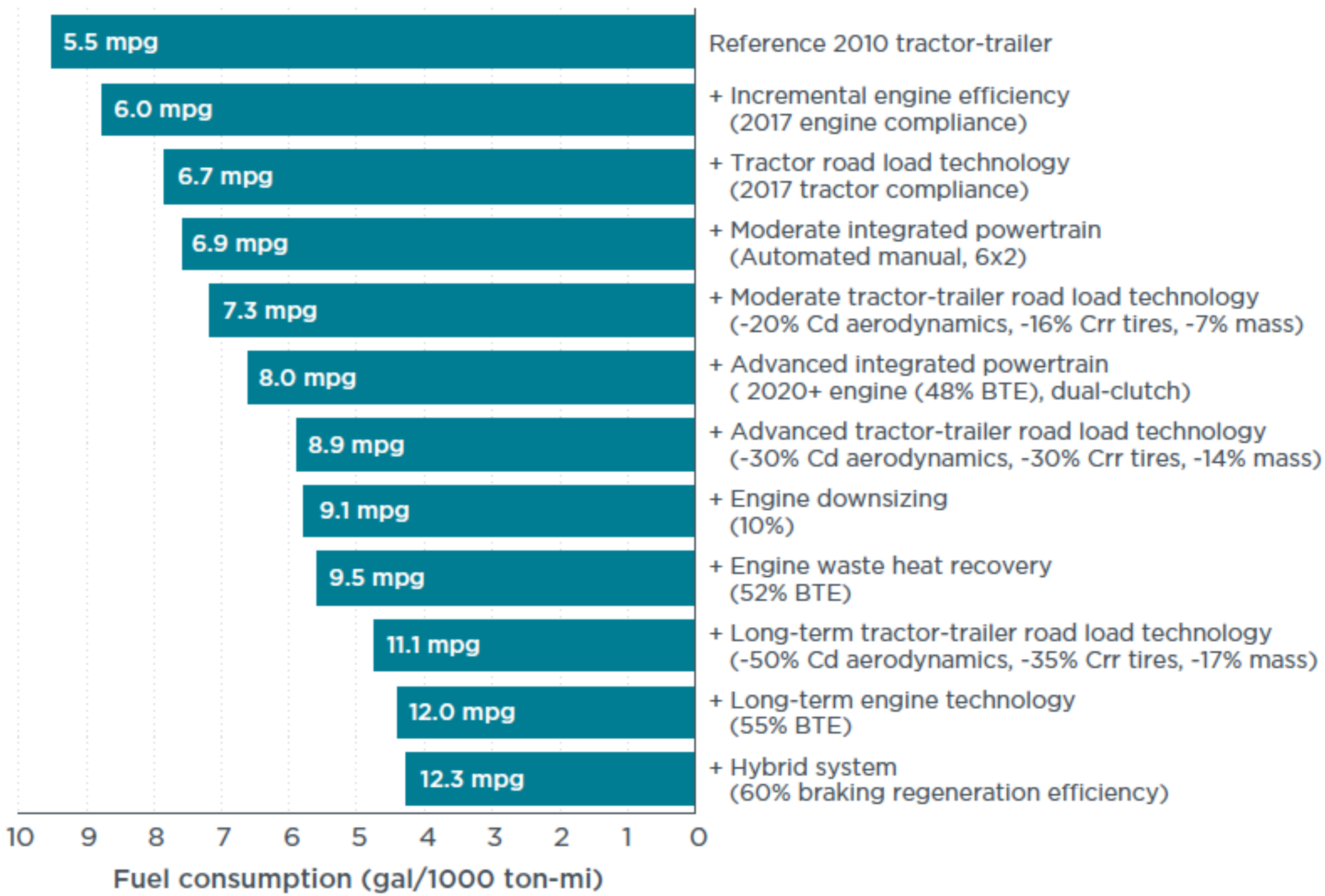
- Simulation modeling of tractor-trailer fuel consumption
  - Incorporate interactions between the technologies
    - Engine, transmission, aerodynamics, tire, mass reduction, etc
  - Modeled in US DOE Autonomie framework
  - Evaluate energy loads and losses over various drive cycles across



Results: Efficiency package fuel consumption

Mid-term technology

Long-term technology



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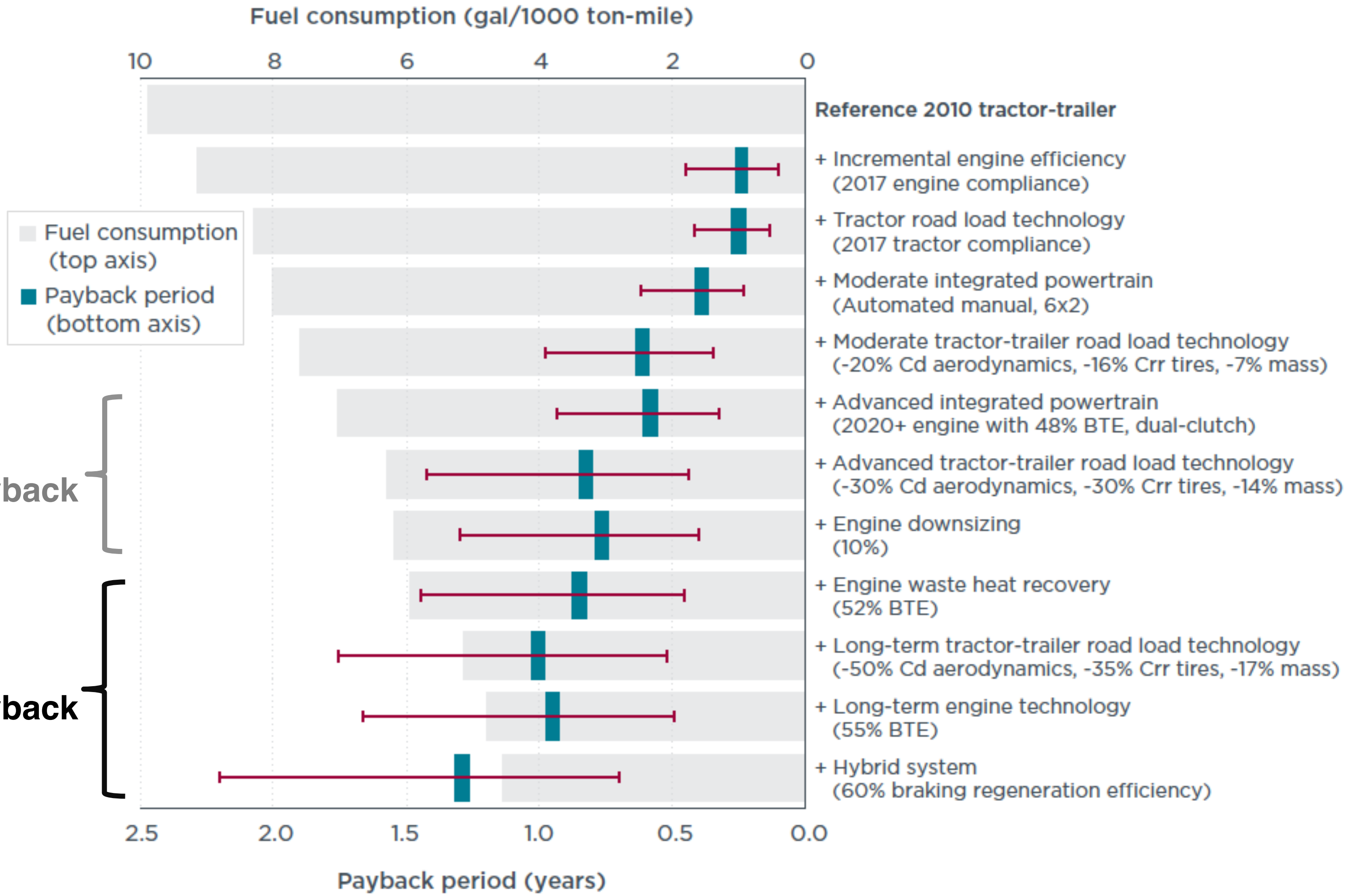
Delgado and Lutsey (2015). http://www.theicct.org/us-tractor-trailer-efficiency-technology
Notes: "real-world" highway cycle with grade, 38,000 lb payload for all packages

Costing methodology and data sources

- Cost estimation methods
  - Review existing cost data (ICF, NAS, AEA, Ricardo, TIAX, etc) for each technology
  - Assemble best estimate low and high costs for the various technologies
  - Cost methodology matched to that used by EPA/NHTSA
    - Include direct and indirect manufacturing costs for each technology
    - Include time- and volume-based learning based on technology maturity
- Key assumptions
  - Three fuel prices: \$3.10, \$4.10, \$5.40 per gal (US EIA AEO 2014, average 2020-2030)
  - Discount rates: 3%, 7%, 10%
  - Vehicle miles traveled by age from EPA/NHTSA RIA
  - Vehicle miles traveled elasticity = -0.05. Based on EPA/NHTSA RIA
  - Operating cost breakdown from EPA/NHTSA RIA
  - Baseline tractor/trailer prices from public market data
  - Fuel efficiency data from simulation “real-world” cycle results (include transients, grade)
  - Three trailers assumed per tractor

RIA = Regulatory Impact Analysis. http://www.epa.gov/oms/climate/documents/420r11901.pdf

Results: Technology payback period



Mid-term technologies: 0.5-1 year payback

Long-term technologies: 1-1.5 year payback

Meszler et al (2015). http://www.theicct.org/us-tractor-trailer-tech-cost-effectiveness ;
Notes: "Error" bars reflect range in tech cost, fuel price ($3.10-$5.40 per gallon), discount rates (3%-10%)

Conclusions

1. *Technology potential in the mid-term* – Available technologies can reduce fuel use per ton-mile by 39% from baseline 2010 technology (by 27% from 2017)
2. *Technology potential in the long-term* – Emerging long-term technologies can achieve a 50% reduction from baseline 2010 technology in the 2025-2030 timeframe.
3. *Diverse technology approaches* – Technology packages with varying levels of advanced load-reduction and engine-based approaches can achieve similar efficiency results.
4. *Regulatory procedure changes* – Regulatory procedure changes are warranted. Direct use of engine map data, streamlined procedures for integrated powertrain approaches, inclusion of grade in test cycles, inclusion of trailers are critical to promote efficiency technologies.
5. *Robust, attractive economic payback periods* – All technology packages are cost effective for $3.10 to $5.40 per gallon diesel and 3-10% discount rates. Middle-estimate technology and fuel prices (i.e.,$4.10 per gallon) have payback periods of 0.5-1.5 years. The most advanced technologies, even at high costs and sustained low fuel prices, offer a 1.4-2.2 year payback.
6. *First-user benefits* – Initial efficiency technology owners would see fuel-saving benefits that greatly exceed upfront technology costs. Technologies that reduce fuel use by 39% offer $100,000-$194,000 in fuel savings and 3-9 times greater benefits than cost over five years .

Sources:
Delgado and Lutsey (2015). http://www.theicct.org/us-tractor-trailer-efficiency-technology
Meszler et al (2015). http://www.theicct.org/us-tractor-trailer-tech-cost-effectiveness

Thanks!

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